Nitrogen and fiber concentration in rumen contents and feces contents of Mongolian gazelles

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Abstract Fecal indicators of nutritional status of wild ungulates were less constrained than that of blood, rumen contents, or urine analyses. Thus, we compared the nitrogen and fiber concentrations of feces with those of the rumen contents of Mongolian gazelles (*Procapra guttrurosa*) in Hulunbeier Grassland. Rumen contents and fecal nutritional concentrations varied in different seasons. Dietary nitrogen concentrations only increased linearly with increase nitrogen concentration in fecal in winter. There was a positive correlation between rumen NDF (neutral detergent fiber) and fecal NDF concentrations. But the regression coefficient was small (r=0.3917). There was a significant regression equation between rumen contents ADF (acid detergent fiber) and fecal ADF concentrations, as well as ADL (acid detergent lignin) concentrations. Nitrogen concentration was found to be negatively correlated with NDF, ADF, and ADL concentrations both in rumen and in fecal compositions. Our data suggest that fecal nitrogen, ADF, ADL concentrations may assess winter dietary qualities that are in protein, crude fiber and lignin concentrations for Mongolian gazelles.

Key words: *Procapra guttrurosa*, Rumen content, Feces, Nitrogen concentration, Fiber concentration.

Introduction

Wildlife managers desire reliable indicators of nutritional status of free-ranging ungulates to assess relationships between habitats and populations. The nutritional condition of ungulates is strongly affected by their food quality, and as ungulates regularly experience nitrogen shortages (White 1978; Robbins 1983), it is particularly important to know the nitrogen concentration of their food plants. One common method of estimating quality of ungulate diets is analysis nutritional quality of forage plants growing in habitats. However, indiscriminately collected forage samples may underestimate nitrogen concentrations in ingested forage because ungulates eat plants and plant parts selectively. Therefore, observations of their feeding behavior have been made (Bryant *et al.* 1980; Hobbs *et al.* 1981; Baker and Hobbs 1982). Such observations are, however, not only time-consuming, but also prone to inaccuracy because wild ungulates do not permit close observation (Tadashi and Takattsuki 1993). Other techniques include fecal indicators of dietary quality (Wofford *et al.* 1985; leslie *et al.* 1989), rumen contents analysis (Klein and Schonheyder 1970; Segelquist *et al.* 1972; Staines and Crisp 1978; Swift 1983), blood analysis (Seal *et al.* 1972), and urinary analysis (DelGuidice and Seal 1988; DelGuidice *et al.*1989). Use of the latter technique is limited to periods of snow cover. Blood analysis requires capturing animals. Analysis of rumen contents is a more accurate direct method, and has been widely used. But it requires the killing of a large number of animals, and therefore it is impractical for use with endangered species and inappropriate for animals living in protected areas or parks. Fecal indicators are not constrained, and may be more useful.

Nitrogen is the most common constituent of feces used to assess dietary quality, and is positively correlated with diet digestibility, lignin, dietary protein (Holechek *et al.* 1982; Wofford *et al.* 1985), and changes in mass (Erasmus *et al.* 1978). However, this method is not always very accurate, particularly when the ungulates of large amount of phenolics and tannins (Robbins 1983). Hobbs *et al.* (1981) noted that undesirable statistical properties of predictive equations, including little within-season variation, might preclude precise estimates of dietary quality from fecal nitrogen concentration. Also, the presence of condensed tannins in some dicotyledonous forage increases the concentration of nitrogen in feces

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(Robbins *et al.* 1987). Leslie and Starkey (1987) warned that fecal nitrogen technique, contending that significant difference estimates for different populations in similar habitats and reflects a real difference in dietary quality. Further, tannins are virtually absent from cured grasses (McLeod 1974), when grasses comprise most of the ruminant diet, fecal nitrogen, and fecal dry matters digestibility appear closely associated with dietary nitrogen concentration and dietary dry matter digestibility respectively (Holechek *et al.* 1982). This has been demonstrated successfully for several ungulates species, including sheep, cattle, and certain cervid (Leslie and Starkey 1987). Information about more ungulates species is needed.

The objective of this study is to compare the nitrogen, neutral detergent fiber (NDF), acid detergent fiber (ANF) and acid detergent lignin (ADL) concentrations of feces with those of the rumen contents of the Mongolian gazelles (*Procapra gutturosa* Pallas) in Hulunbeier Grassland, Inner Mongolia, China, in order to test the possibility of using fecal indicators as an effect indicator of Mongolian gazelles forage quality.

Study areas

Study area is in Xiqi where is situated in the southwestern part of Hulunbeier Grassland (115° 00'~117°48' E, 47°39'~49°50' N) and is a main distribution region of Mongolian gazelles in China. Climate type belongs to continental arid in temperature zone. Annual temperature is averaged -1°C. Temperature extremes were -35.4°C and 34.6°C, and average total annual precipitation around study area is less 250 mm, 60% of yearly precipitation occur from July to September.

Vegetation type belongs to the Europe-Asia Plateau Vegetation Region. Main plateau plant types include *Stipa grandis* steppe, *Aneurolepididum chinense* steppe. Dominant species mainly include *Stipa grands, S. krylovii, Aneurolepidium chinense, Agropyron cristatum, Koeleria cristatta, Clestogenes squarrosa, Allium prostratum, Carex duriuscula, Caragana incrophylla* etc.

Materials and methods

Materials

A total of 53 samples were collected from the Mongolian gazelles killed for hunting near the border of China-Mongolia in winter (in February), spring (in April), summer (in June), and autumn (in November) from 1997 to 1998. Immediately after being shot the gazelles were sexed, weighed, and the autopsied. About 500 ml of rumen contents and all of fecal pellets in the recta were collected, and frozen within -15°C refrigerator.

Methods

Both the rumen contents and fecal pellets were allowed to air dry, because air-drying had no effect on nitrogen concentration of feces (Jenks *et al.* 1990). Then, they were oven-dried at 65°C for 24 h and grounded in a Wiley mill to pass through 1 mm sieve. Nitrogen concentration was determined using a C-N analyzer (C-N corder, MT-500, Yanaco Co., Ltd.), and fiber, lignin concentration determined by the NDF, ADF and ADL method (Goering and Van Soest 1970).

Results

There were clear seasonal variations in nitrogen, NDF, ADF, and ADL concentrations of rumen contents and feces (Table 1). Nitrogen concentration of rumen contents, among a year, was lower in autumn and winter than that of spring and summer. Spring (4.305%) and summer (4.254%) nitrogen in rumen samples twice as much as that of autumn (2.153%) and winter (2.606%) samples. The nitrogen concentration of fecal samples was in spring samples (3.960%) significantly higher than that of other seasonal samples, although the differences were smaller than those for rumen contents. And nitrogen concentration of fecal samples was similar to that in summer (2.310%), autumn (2.705%), and winter (2.606%). The result turned out contrary to nitrogen concentration. The NDF, ADF, and ADL concentrations were lower in both rumen contents and feces samples in spring and summer than those in autumn and winter. And the difference was significant (F =11.163, d.f. =5.18, $P < 0.01$). NDF concentration of both rumen contents and feces samples was higher than ADF and ADL concentrations of corresponding samples in every season. ADL concentration was the lowest in rumen contents and feces to compare with that of NDF and ADF, and their differences also were significant (F = 18.935, d.f. =5.18, $P < 0.01$).

The fecal nitrogen concentration of each sample was plotted against the nitrogen concentration of rumen contents (Table 2). A positive correlation was found between them. For all samples, the correlation was weak (r=0.310 5). However in winter, the correlation index was stronger (r= 0.721 9, n = 20, F = 22.118, d.f. = 8.10, $P < 0.01$). Contrarily in spring and summer, the correlation was very weak (spring: r = 0.210 1, summer: r = 0.201 9). There was a positive correlation between fecal NDF and rumen contents NDF concentration, but the regression coefficient was small because of great variation among the samples (r = 0.391 7). There were also positive correlation between ADL of feces and rumen contents. The re-

gression coefficients were very significant (ADF: r = 0.800 6, F = 118.970, $P < 0.01$; ADL: r = 0.725 8, F = 98.096, $P < 0.01$, Table 2). In time, nitrogen concentration was found to be negatively correlated with NDF, ADF, and ADL concentration both in rumen contents and in feces samples. And the correlation was in fecal samples stronger than in rumen contents samples. In fecal samples, there was not a significant correlation between NDF concentration and ADF concentration (Table 3). But there was a strong regression coefficient between ADF concentration and ADL concentration (F = 78.596, $P < 0.01$).

Table 1. Nitrogen, NDF, ADF, and ADL percentage (%) in rumen contents (RC) and in feces of Mongolian gazelles in different seasons

Nutritional composition		Winter		Spring		Summer		Autumn	
		Mean value /%	SD	Mean value /%	SD	Mean value /%	SD	Mean value /%	SD
Nitrogen	RC	2.606	0.076*	4.305	0.146	4.254	0.431	2.153	0.097
	Face	2.606	0.168	3.960	0.527	2.310	0.146	2.705	0.261
NDF	RC	59.443	2.870	42.174	5.024	42.909	4.006	57.482	2.454
	Face	41.951	4.035	33.282	4.952	43.040	3.915	41.903	5.398
ADF	RC	39.325	2.918	27.642	1.452	28.716	1.391	37.392	3.235
	Face	35.803	2.803	24.783	2.662	26.517	1.204	33.332	3.342
ADL	RC	16.207	1.553	6.740	1.622	8.216	1.396	16.261	0.669
	Face	16.778	2.425	8.652	1.739	11.137	0.882	17.195	1.555

Note: "RC" stands for "Rumen content". *--The correlation is significant.

Table 2. Simple correlation of nutritional composition between rumen contents (y) and feces (x)

Composition	Regression equation	Sample number	Correlation coefficients /%
Nitrogen concentration	Y = 2.390 5 + 0.165 3 x	52	31.05
NDF concentration	Y = 32.294 1 + 0.547 2 x	51	*39.17
ADF concentration	Y = 8.974 2 + 0.827 7 x	52	**80.06
ADL concentration	Y = 2.831 0 + 0.754 6 x	49	**72.58

Note: * (**) --The correlation is significant (very significant).

Table 3. Coefficients of simple correlation among fecal components

Item	N	NDF	ADF	ADL
N	1			
NDF	- 0.921 2**	1		
ADF	- 0.870 3**	0.349 6	1	
ADL	- 0.709 7**	0.544 9	0.884 1**	1

Note: N stands for nitrogen concentration. ** --The correlation is very significant.

Discussion

Dietary quality of ungulates can be mainly decided by the nutritional composition of forages. The variations of nutritional composition of forages are closely relation with the phenology of plant. The cell contents including crude protein, water, and some minerals etc, are the highest in growth period. But the contents are gradually reduced in following period. Specially, in winter, these compositions reduce to the lowest. The variations of cell wall turn out contrary to that model. The crude fiber and lignin concentration is increased in rope period by degrees. The variations also exist to our study. Nitrogen concentrations of various rumen contents and feces in spring and summer are higher than that in autumn and in winter. Only the variation in fecal samples was not clear relatively. Nitrogen concentration was found to be negatively correlated with NDF, ADF, and ADL concentration both in rumen contents and in fecal composition. Moen (1973) who studied on roe deer (*Capreolus capreolus*) has indicated a similar relation. And Tadashi (1993) who studied on sika deer (*Cerves nippon*), showed that fiber concentration of ruminants pasture declined in summer when protein concentration increased. Several studies have compared fecal nitrogen concentration with dietary nitrogen concentration and have found good correspondence between them. But it was weaker that the regression coefficient in Mongolian gazelles (r = 0.310 5) than in most other studies, for example, r = 0.97 for wapiti (*Cervus elaphus canadensis*), Mould and Ribbins, 1981; r = 0.78~0.88 for domestic cattle, Holechek *et al.*, 1982; r = 0.79 for mule deer (*Odocoileus hemionus*), Mubanga *et al.*1985; r = 0.95 for moose (*Alces alces*), Renecker and Hudson 1985.

Wofford *et al.* (1985) reviewed studies that showed that fecal nitrogen dietary quality associations deteriorate when dietary nitrogen levels were > 2.8%. Such a relationship is demonstrated by date from

spring (nitrogen percentage = 4.305%) and summer (nitrogen percentage = 4.254%, Table 1). It Suggests that a nonlinear relationship between fecal nitrogen and dietary nitrogen concentrations may occur at high dietary nitrogen levels, because tannins bind with protein to form complexes that are insolable in rumen contents (Tadashi *et al.* 1991). From late November through early February, dietary nitrogen concentration in our study samples was < 2.8%, dietary tannin levels were low, and fecal nitrogen levels tracked changed in dietary nitrogen concentrations rather closely. Therefore, our data did not support Seip and Buinell (1985) contention that a significant difference between different seasons fecal nitrogen estimated for a single population in similar habitats, reflects a real difference in dietary quality. We suggest that only in winter can be used fecal nitrogen concentration to estimate Mongolian gazelle's dietary quality.

According to our study, there was a small regression coefficient between rumen NDF and fecal NDF concentration, although the correlation was significant. One possible reason should be that NDF contains various indigestible materials such as lignin and crude silicaceous acids, which results in great variability in proportions of indigestible materials in feces. Therefore, it seemed difficult to estimate rumen NDF concentration from fecal NDF concentration. But there was a positive correlation between rumen ADF and fecal ADF concentration (r = 0.800 6), and between rumen ADL and fecal ADL concentration (r = 0.725 8). Their correlation was very significant. We consider that rumen crude fiber concentration can be estimated from the fecal ADF and ADL concentration.

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